DON HONORIO VENTURA STATE UNIVERSITY

Arduino Autonomous Barricade Avoidance System

A Case Study
Presented to the College of Engineering and Architecture
Department of Computer Engineering
Bacolor, Pampanga

In Partial Fulfillment of the Requirements for the Subject
CpE – FCS 313 Feedback and Control System

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INTRODUCTION

In the dynamic landscape of computer engineering education, the integration of hands-on projects plays a pivotal role in bridging the gap between theoretical knowledge and practical application. According to Smith (2019), technology is a creative expression of human culture, imbued with human values and strivings in all their contradictory complexity. As technology continues to advance, there is a growing demand for engineers who not only comprehend complex concepts but can also apply them in real-world scenarios. This study aims to address this need by introducing a hands-on project involving the development of an Arduino obstacle-avoiding car.

As initially applied, computer engineering applied aspects of digital logic design from computer science to the design of microprocessors and technological systems (Kenebrew, 2023). It encompasses a diverse array of fields, from embedded systems and control theory to robotics and signal processing. The intersection of these disciplines is evident in the design and implementation of autonomous systems, particularly those capable of navigating and avoiding obstacles in their environment. This case study centers on the creation of a small-scale, autonomous vehicle using Arduino microcontrollers and sensors, providing us students with a practical opportunity to apply their theoretical knowledge in a tangible, real-world context.

The significance of this study lies in its potential to enhance the educational experience of computer engineering students. By undertaking the construction and programming of an obstacle-avoiding car, students gain hands-on experience in embedded systems development, algorithm implementation, and control theory. Moreover, this project encourages creativity, problem-solving skills, and collaborative learning, mirroring the multifaceted challenges faced by professionals in the field.

As aspiring computer engineering students, the researcher's collaborative effort to construct an Arduino obstacle-avoiding car extends beyond the confines of a classroom project. By immersing themselves in the development of this autonomous vehicle, the researchers are not merely solving an academic problem but actively engaging with a challenge that has far-reaching applications in real-world scenarios.

NaviguinoRover based on the group of researchers is an original, self-made word that is a combination of:

Navigation: This indicates that the device is designed with a focus on navigation capabilities, suggesting that it can move and operate autonomously with some level of directional control.

Arduino: This signifies that the device is built using Arduino technology, highlighting the use of a popular open-source electronics platform known for its versatility in programming and hardware interaction.

Rover: This term refers to a vehicle designed for traversing various terrains. In the context of the portmanteau, it suggests that the device is a mobile platform capable of navigating through different environments.

The purpose of the **NaviguinoRover** is to serve as a versatile and navigational Arduino-based platform designed for educational exploration and experimentation in robotics and autonomous systems. By integrating navigation capabilities with the flexibility and accessibility of Arduino technology, the **NaviguinoRover** aims to provide an accessible tool for students, and researchers to delve into the principles of autonomous navigation, obstacle avoidance, and robotics. This research endeavors to contribute to the field by offering an open-source and customizable platform that fosters hands-on learning, innovation, and the development of skills in robotics and electronics.

The purpose of the study is to apply the learnings and understandings of the proponents in an actual output that can help allied fields. It examines the potential advancements that computer engineers may create and develop with the use of Arduino ultrasonic sensors with the help of an in-depth understanding of the said predicament.

BACKGROUND OF THE STUDY

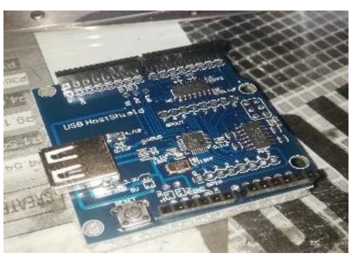
Technology is quite literally the lever for being able to take natural resources and able to make something better out of them (Andressen, 2020). It became one of the reasons why our world is now on another version compared to the past years and obviously, the knowledge and goals will continue through generations. According to Thiel (2014), properly understood, any new and better way of doing things is technology and by technology, we typically mean the knowledge and instruments that humans use to accomplish the purpose of life (Friedel, 2007) he also notes that technology can, indeed, be defined as a pursuit of power over nature. Fernald (2014) defined technology in a presentation entitled “Technology and the American Economy: Or, What’s the New Normal?” as an ability to convert society’s resources (labor and capital) into output (goods and services that we value). Nowadays, it is one of the foundations of our income that benefits all aspects of our society. Humans are indeed innovative and resourceful powers most of the time that the world needs. According to Arthur (2009), the first and most basic one is a technology is a means to fulfill a human purpose.

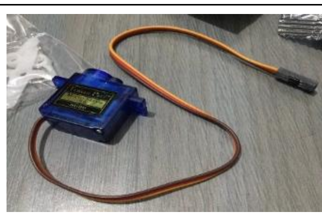
Generally, computer engineering is a vital field in today's world. Computer engineering programs typically focus on the theoretical foundations related to machine and algorithm designs used to develop computers, producing highly skilled design and research designs (Jacobson and Evans, 2010). Computer engineers also perform a variety of other important tasks, from developing and improving wireless networks to allow for communication across the world to the creation of operating systems powered by new hardware and high-level research that expands the boundaries of computer science and computer engineering as a whole (Gani, 2022). Various computer engineers have the opportunity to create robotic technology for either private or public purposes. According to Gani (2022), robotics is a branch of electrical engineering, computer science, and mechanical engineering that deals with the designing, constructing, operating, and application of robots that involve computer systems for the control, information processing, and sensory feedback of robots.

Throughout the period, Arduino has served as the brain of countless projects, ranging from simple household objects to complex scientific instruments. A global community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, and what they have contributed adds up to an incredible amount of accessible knowledge that can be of great assistance to both novices and experts. Arduino is an open-source electronics platform based on easy-to-use hardware and software; was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming (Arduino. CC, revised 2018). According to Cook (2018), ultrasonic sensors work by emitting sound waves at a frequency too high for humans to hear. It is a great deal to combine ultrasonic sensors with Arduino to come up with an output that can be useful in our daily lives.

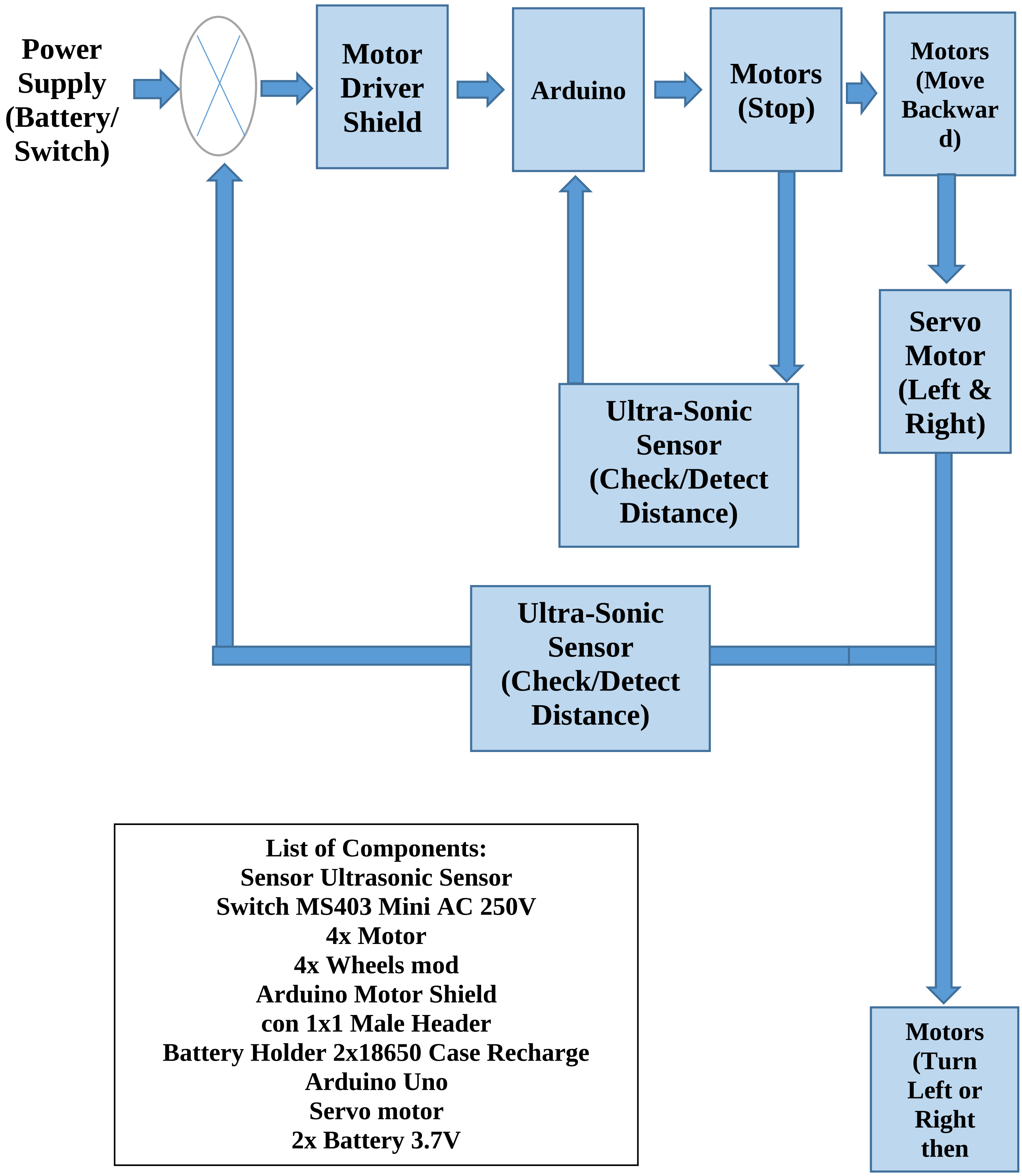
The proponents conducted this study to show and apply their knowledge and understanding in an actual output that may help and be used by other individuals to innovate and improve the use and functions that may benefit society. The content of this study can help possible contributors considering that the testing and results underwent a trusted process.

MATERIALS: List of Components

Components	Name of Component	Function/Role
	**Ultrasonic Sensor**	This component is used to measure distances by sending ultrasonic waves and detecting their reflections.
	**Switch MS403 Mini AC 250V**	This component is used as a manual ON/OFF switch to regulate the system's power supply.
	**DC TT Gear Geared Motor and Wheel**	This component is used to execute avoidance strategies and navigate through its surroundings.
	**Mod Arduino Motor Shield**	Used to control and drive motors that enable the movement of the system.

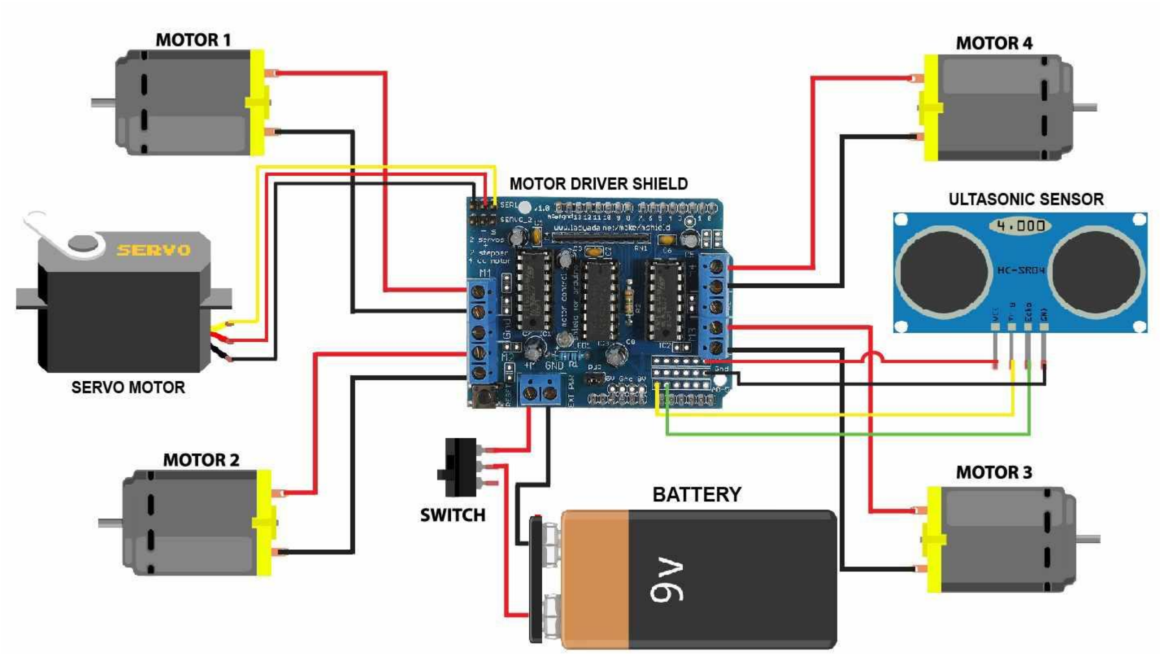
	**Con 1x1 Male Header**	This component is used for connecting sensors, components, or additional components to the Arduino board, among other things. It allows it possible for a safe, modular connection, which makes it easier to add multiple components of hardware into the system.
	**Battery Holder 2x18650 Case Recharge**	This component serves as our system's power source. It makes the Arduino system operate and suited for applications like autonomous systems by enabling it to function without a direct power source.
	**Arduino Uno**	This is the brain that helps us to control our motor to navigate and avoid obstacles. All operations and exchange of electrical charges take place at the Arduino Uno.
	**Servo Motor**	This is a component that help us to survey the environment, navigate and detect the obstacles to avoid collisions.

BLOCK DIAGRAM



List of Components:
Sensor Ultrasonic Sensor
Switch MS403 Mini AC 250V
4x Motor
4x Wheels mod
Arduino Motor Shield
con 1x1 Male Header
Battery Holder 2x18650 Case Recharge
Arduino Uno
Servo motor
2x Battery 3.7V

SCHEMATIC



Created in TinkerCad

The research design unfolds with a strategic sequence: initiating from the battery, the primary power source, the system progresses to the motor driver seamlessly integrated with the Arduino. Activation of the motors follows, with an initial pause for stabilization. Subsequently, the ultrasonic sensor conducts a thorough assessment of the front distance, permitting forward movement only if the criteria are met. Upon detecting an obstacle, the system intelligently halts forward motion, prompting a subsequent reverse maneuver by the motors. Following this, the servo motor engages in lateral movements, complementing the ultrasonic sensor's assessment of distances to the left and right. This synchronized interplay of components ensures a comprehensive and responsive navigation approach, exemplifying the sophisticated dynamics embedded within the researcher’s research model.

TESTING OF CONTROL SYSTEM

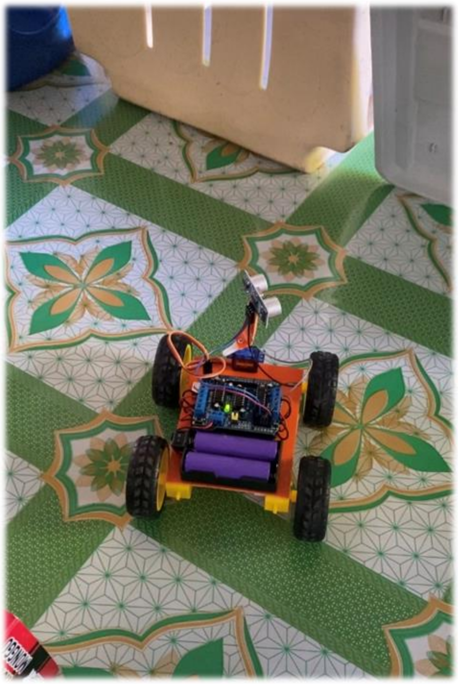
Embarking on the creation of the Arduino Obstacle Avoiding Rover, aptly named **NavguinoRover**, the researchers undertook a hands-on approach. Each component was meticulously assembled, offering a ground-up reconstruction. This deliberate process facilitated exhaustive testing and enabled a series of trial-and-error sessions for code refinement. This phase signifies the transition from theoretical constructs to tangible reality, emphasizing the team's dedication to transforming conceptual frameworks into a functional prototype. The **NavguinoRover** stands as a testament to the researchers' commitment to merging theoretical insights with practical application in the dynamic realm of robotics.

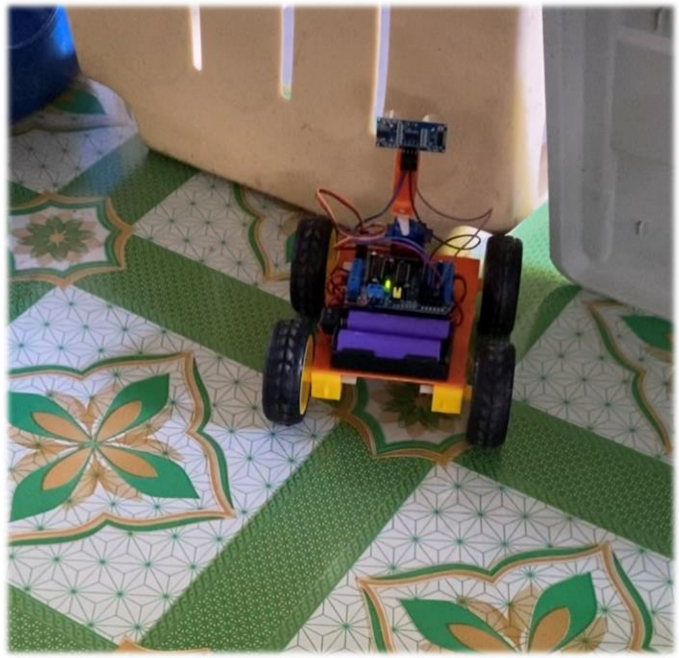
Executing the code on the Arduino Uno platform through the Arduino IDE, this code snippet illustrates a meticulously crafted implementation for a robotic control system. Harnessing the capabilities of the AFMotor, NewPing, and Servo libraries, the code orchestrates the intricacies of motor control, distance sensing, and servo motor manipulation. Highlight features encompass the utilization of the NewPing ultrasonic sensor for precise distance measurements, the AFMotor library for seamless DC motor control, and the Servo library for precise directional adjustments. The setup phase initializes the servo motor and conducts an initial distance measurement, setting the foundation for subsequent operations. In the continuous loop, the code vigilantly monitors distances, dynamically adapting the robot's movement based on real-time sensor input. Specifically designed to address obstacles, the code prompts the robot to pause briefly and reverse its trajectory when the detected distance falls below or equals 15 units. This implementation not only demonstrates a fundamental obstacle avoidance behavior but also underscores the versatility and applicability of Arduino Uno in the realm of mobile robotics.

The Code:

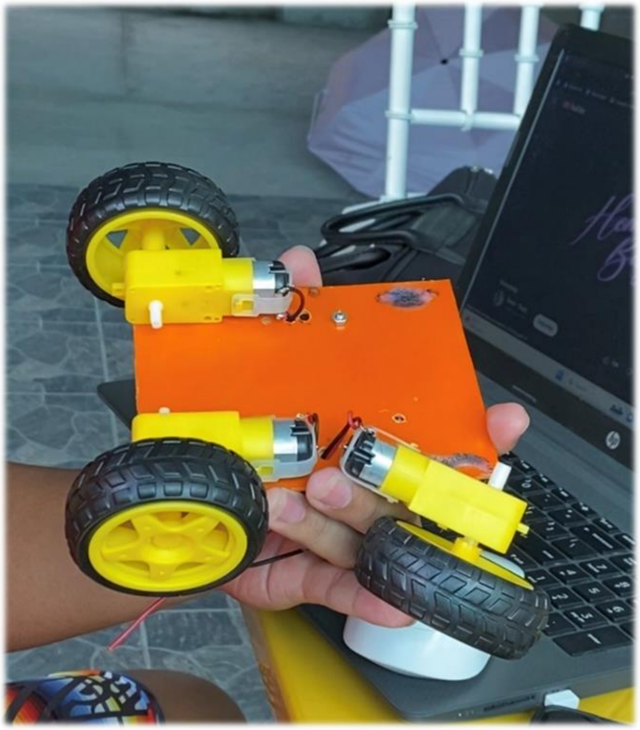
```
#include <AFMotor.h>
#include <NewPing.h>
#include <Servo.h>

#define TRIG_PIN A0
#define ECHO_PIN A1
#define MAX_DISTANCE 200
#define MAX_SPEED 190 // sets speed of DC  motors
#define MAX_SPEED_OFFSET 20

NewPing sonar(TRIG_PIN, ECHO_PIN, MAX_DISTANCE);

AF_DCMotor motor1(1, MOTOR12_1KHZ);
AF_DCMotor motor2(2, MOTOR12_1KHZ);
AF_DCMotor motor3(3, MOTOR34_1KHZ);
AF_DCMotor motor4(4, MOTOR34_1KHZ);
Servo myservo;

boolean goesForward=false;
int distance = 100;
int speedSet = 0;

void setup() {

  myservo.attach(10);
  myservo.write(115);
  delay(2000);
```

```
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
}

void loop() {
 int distanceR = 0;
 int distanceL =  0;
 delay(40);

 if(distance<=15)
 {
  moveStop();
  delay(100);
  moveBackward();
  delay(300);
```





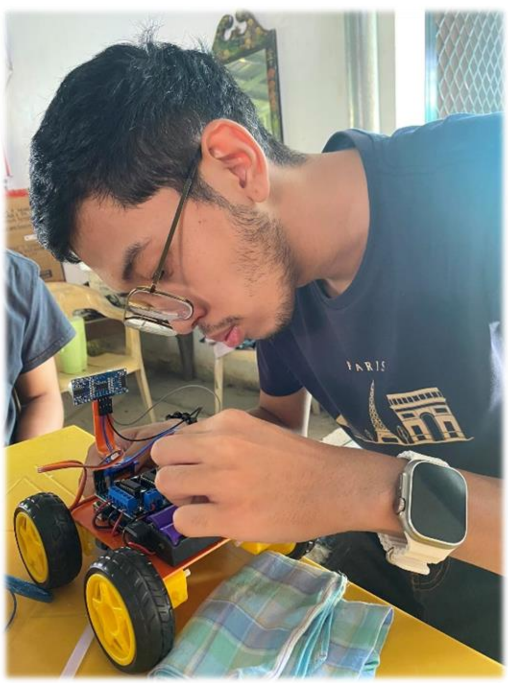
In the pursuit of refining the NavguinoRover's navigation capabilities, the researchers systematically addressed challenges encountered during the code development phase. Faced with occasional collisions with walls and obstacles arising from the limited detection range of the Ultrasonic Sensor, the team conducted thorough trial-and-error iterations to enhance the code's performance. A pivotal modification involved augmenting the Ultrasonic Sensor's detection range, resolving issues and contributing to the overall improvement of the robot's obstacle avoidance functionality. This iterative process exemplifies the dedication to overcoming challenges and fine-tuning the NavguinoRover's navigation for enhanced efficiency.




Throughout the researchers endeavors, a notable challenge emerged surrounding the recurrent disassembly of the DC TT Gear Geared Motor and Wheel. Despite the initial efficacy of the Glue Stick adhesive, the application faced limitations when subjected to substantial force, resulting in the detachment of the motor and wheel from the PCB. To mitigate this issue, the researchers strategically addressed it by applying an increased quantity of Glue Stick, fortifying the connection to prevent unintended disassembly. This adaptive solution exemplifies the commitment of the researchers to refining the reliability of pivotal components within the system, showcasing the iterative and problem-solving nature of the researchers journey.

RESULT






Having successfully addressed all issues, the research team is now meticulously applying the final touches to complete the **NavguinoRover.** This phase marks the culmination of efforts, resulting in a fully functional and operational output. The attention to detail and comprehensive problem-solving throughout the development process ensures that the **NavguinoRover** stands as a testament to the team's commitment to excellence in producing a refined and successful research outcome.

This is the completed prototype of **Arduino Autonomous Barricade Avoidance System** or **NavguinoRover.**

Project Implementation and Achievements:

The implementation of the Arduino obstacle-avoiding car, known as the **NavguinoRover**, materialized through a comprehensive and collaborative effort. The integration of hands-on projects in computer engineering education proved pivotal, bridging the theoretical-practical gap and aligning with contemporary technological advancements. This study's primary objective was to empower students with a practical opportunity to apply theoretical knowledge, fostering a holistic understanding of computer engineering concepts.

Educational Significance:

The hands-on development of the **NavguinoRover** served as an effective educational tool. Computer engineering students engaged in the construction and programming phases, gaining valuable experience in embedded systems development, algorithm implementation, and control theory. The project's multidisciplinary nature encouraged creativity, problem-solving skills, and collaborative learning—a reflection of the real-world challenges encountered by professionals in the field. The NavguinoRover project contributed to enriching the educational experience by providing a tangible link between classroom theories and practical applications.

Challenges and Solutions:

As with any innovative endeavor, this case study faced challenges. Issues pertaining to the adhesive strength of the DC TT Gear Geared Motor and Wheel were identified during the trial phase. The application of an excessive amount of Glue Stick proved instrumental in fortifying the connection, mitigating the risk of detachment and contributing to the overall stability of the rover. This adaptive solution exemplifies the importance of practical problem-solving and resilience in the face of challenges encountered during real-world project implementation.

Intersection of Disciplines:

Computer engineering, a field rooted in digital logic design and microprocessor technology, seamlessly intersects with diverse domains such as embedded systems, control theory, robotics, and signal processing. The **NavguinoRover** project showcased the integration of these disciplines, particularly in the design and implementation of an autonomous system capable of navigating and avoiding obstacles. The intersection of theory and practice in this project mirrors the multifaceted challenges faced by professionals in the evolving landscape of computer engineering.

Technological Foundations:

The project's utilization of Arduino microcontrollers and ultrasonic sensors underscored the pivotal role of technology in shaping contemporary solutions. Arduino, as an open-source electronics platform, provided an accessible and versatile foundation for the **NavguinoRover**. The integration of ultrasonic sensors offered a sophisticated means of distance measurement, aligning with Arthur's perspective on technology as a means to fulfill human purposes. The project exemplified the fusion of technology and innovation to address real-world challenges.

Future Implications and Applications:

The successful development of the **NavguinoRover** holds promise for future applications and advancements within computer engineering. The integration of Arduino microcontrollers and ultrasonic sensors presents opportunities for the creation of innovative solutions with potential applications in various fields, including robotics, automation, and environmental monitoring. The study's purpose, to apply and understand the potential advancements enabled by Arduino ultrasonic sensors, lays the groundwork for future research and development in allied fields.

CONCLUSION

This case study demonstrates the successful application of the learnings, explorations, and understanding in an actual product. With the Arduino with ultrasonic sensor, the proponents developed a beneficial product that can help allied fields with their work. It may be used and reconstructed by the next generation for other functions.

With the trial-and-error code testing, the researchers completely produced the **NaviguinoRover**. **NaviguinoRover** is a self-made; and aims to provide an accessible tool for students, and researchers to delve into the principles of autonomous navigation, obstacle avoidance, and robotics. The result and testing show an interrelationship between the system and the prototype assembled. This study seeks to contribute to the field of study by providing an obtainable and adaptable framework. A platform that enables experiential learning, innovation, and the improvement of robotics and electronics skills.

Furthermore, the study delves into the background of technology, emphasizing its transformative role in society. The definition of technology as a means to fulfill human purposes, coupled with the ever-evolving landscape of computer engineering, underscores the importance of innovation and resourcefulness in addressing contemporary challenges.

The introduction of Arduino technology and ultrasonic sensors within the study provides a practical dimension to the theoretical knowledge, showcasing the versatility of these tools in creating useful outputs. The collaborative effort of the researchers serves as a testament to the potential advancements that computer engineers can achieve, offering a platform for educational exploration, experimentation in robotics, and autonomous systems.

In conclusion, this study not only contributes to the field by offering a customizable, open-source platform but also highlights the broader impact of technology on society. By applying their learnings and understandings in the development of the **NaviguinoRover**, the proponents aim to inspire future innovations and improvements, providing a valuable resource for individuals seeking to contribute to the ever-evolving field of computer engineering.

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